Energy ITS: Another Application of Vehicular Communication

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Outline

• Research Outline
  – Background
  – Research Objects
  – Research Schemes
  – A Case of Study

• Research Challenges
Background

• Why and how contribute to the future wireless networks?
• Intelligent Transport System (ITS), Global warming and CO₂ emissions
• The ITS can contribute to the energy saving on two aspects:
  – One is to eliminate the congestion, which enables each vehicles to drive at the fuel optimal speeds;
  – The other is to provide means for modal shift, which reduces the traffic volume.
• CO₂ emission reduction and energy saving
  – Traffic light control and ETC
• Eco-Driving
• Vehicle-to-grid
Research Objects (1/2)

• Vehicles short time stops cost more fuel consumptions

![Diagram of CO2 emissions and vehicle performance]

Fig.1 Vehicles CO₂ emissions

• Smoothing vehicles travel – eco-driving
• How? Using ETC installed vehicles to control the traffic lights
  • Traffic light control for reduce waiting time
  • Given recommended speed for decreasing stop times
Research Objects (2/2)

For reducing CO$_2$ emissions

*Using traffic light control scheme to smooth vehicles travels.*

For smoothing vehicles travels

*Real time traffic flow information is needed*

For Real time traffic flow detection

*Road-to-vehicle and vehicle-to-vehicle communication*
Research Scheme (1/6)

- **Real time traffic flow detection**

1. ETC is used for automatic toll collection in highway by non-stop charging.

2. By the antennas (Road Side unite (RSU)) in highway lanes and ETC in-vehicle devices (On Board Unite (OBU)).

3. Wireless Communication between OBU and RSU is based on Dedicated Short Range Communications (DSRC)
Research Scheme (2/6)

Real time traffic flow detection

Fig. 2 Traffic Flow Detection Model
Research Scheme (3/6)

Fig. 3 An Intersection Model

Traffic Control center
Research Scheme (4/6)

Smoothing vehicles travel

1. Traffic light control
   Aim to: reduce vehicles waiting time by control the vehicles passing orders.

2. Speed control
   Aim to: reduce vehicles’ probable stop times, and give the drivers recommended speeds for passing intersection with less stop times.
Research Scheme (5/6)

- **Smoothing vehicles travel**
  - Traffic light control algorithm:
    - The goal of traffic light control is to reduce the detected vehicles’ waiting time.
    - We have tried and improved several algorithms:
      - Decision tree control algorithm
      - Brouch and bound control algorithm
Research Scheme (6/6)

- **Smoothing vehicles travel**
- **Speed Control----Recommended speed**
  - for reducing vehicles’ probable stop times, and give the drivers recommended speeds for passing intersections with less stop times.
- The needed information are as follows:
  - (1) Distance $d$
  - (2) Current light color, and current traffic light duration time or called cycle, each color's duration time, $T_g$, $T_r$, $T_y$
  - (3) Remaining time of current light, $L_g$, $L_r$, $L_y$

- **by the above schemes, the CO$_2$ emissions can be indirectly reduced**
A case of study (1/4)

• Case Introduction

- Compared with fixed control scheme, the simulation aims at average waiting time, stop times, non-stop rate and CO$_2$ emissions and reductions.

Fig.4 Simulation Map

Fig.5 Fluctuation of Traffic Volume
A case of study (2/4)

- Non-stop passing rate & average stop times from S to D

Fig. 6 Non-stop Passing Rate from S to D (R1 and R2)

Fig. 7 Average Stop Times from S to D (R1 and R2)
A case of study (3/4)

- Average waiting time from S to D & Non-stop passing rate in intersection 3

Fig. 8 Average Waiting Time (R1 and R2)

Fig. 9 Non-stop Passing Rate (Intersection 3)
A case of study

• Average CO$_2$ reduction from S to D (R1 and R2)

Fig.10  CO$_2$ Reduction Percentage from S to D (R1 and R2)
Challenges

1. Not all vehicles installed the ETC devices, the communication among V2V and V2I may unavailable.

2. Not all drivers obey the recommended speed, introduce a index to indicate the obey percentage.

3. Interferences exit when communication happens (V2V, V2I). Propose a Headway based emergency message probabilistic propagation.
Thanks For Your Attention!
Comments And Questions Are Welcome!
Appendix

• **CO₂ Emission Estimation Model**

\[ E = 0.3K_C \cdot T + 0.028K_C \cdot D + 0.058K_C \cdot Aee \]

\[ Aee = \sum_{k=1}^{K} \sigma_k (v_k^2 - v_{k-1}^2) \]

• **E**: CO₂ emissions [g]
• **Kc**: Coefficient between gasoline consume and CO₂ emissions
• **D**: Travel distance [m]
• **T**: Travel time for the distance D[sec]
• **\(v_k\)**: the speed at time k[m/s]
• **\(\sigma_k\)**: when accelerating it equals to 1 and otherwise equals to 0.